MONITORING ATMOSPHERIC MERCURY SPECIES IN MICHIGAN: YEAR 1 ANNUAL REPORT

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MONITORING ATMOSPHERIC MERCURY SPECIES IN MICHIGAN

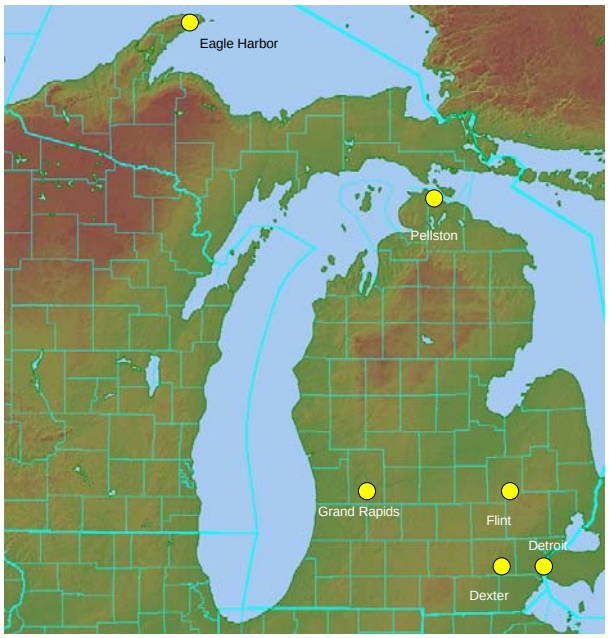
I. Abstract: This project addresses the persistent, bioaccumulative toxic pollutant of concern – mercury (Hg). Hg is a pollutant that once released into the environment can be converted to an extremely persistent, bioaccumulative organic form, methylmercury. Methylmercury can then build up in organisms high within the food chain, such as fish, posing a risk to wildlife and humans that consume these fish. Hg continues to be targeted as a pollutant of concern for source identification, reduction and/or elimination through a variety of state, federal, and international efforts. Since 1988, the Michigan Department of Community Health has issued a statewide fish consumption advisory for Hg for all of Michigan's inland lakes, and for certain species of fish in three of the Great Lakes and Lake St. Clair. The atmosphere has been determined to be the most significant source of Hg to Michigan's inland lakes and for some of the Great Lakes (1-3). However, quantification of the levels of reactive gaseous mercury (RGM), the most important form for deposition, has yet to be accomplished in any systematic manner in Michigan or anywhere in the Great Lakes Region. Since RGM is primarily emitted from anthropogenic point sources, this project assesses the levels of speciated ambient Hg and Hg deposition in three urban areas in Michigan. This project also continues the long-term event-based Hg deposition record at three rural sites in Michigan to allow trend analysis and determination of background Hg levels for estimation of Hg contributions from local urban sources. Finally, this project will investigate Hg concentrations at one select urban lake, known to have elevated Hg fish tissue concentrations.

II. Statement of Problem

Because Hg is a pollutant that is persistent in the environment and has the bioaccumulative potential to become up to a million times higher in predatory aquatic species than the surrounding surface water, it is a critical pollutant earmarked for "virtual elimination" by various state, regional, national and international programs. While Hg is naturally occurring, it is the anthropogenic releases that are the focus of the reduction efforts. Studies have documented that natural Hg emissions comprise only one-third of all Hg emissions to the global environment (4). In Michigan, thousands of pounds of Hg continue to be released into the environment, primarily into the atmosphere (5). The purpose of this project is twofold, first to assess concentrations of Hg species (elemental and reactive gaseous, particulate phase) in ambient air and in deposition in urban and rural locations. Second, Hg concentrations on one select urban lake, known to have elevated Hg fish tissue concentrations will be investigated. The specific objectives are as follows:

a. **To assess spatial and temporal trends of speciated atmospheric Hg in both rural and urban areas at six atmospheric Hg monitoring sites.** Climatological variability requires several years of monitoring data to adequately capture year-to-year changes in weather patterns and resulting Hg deposition. Because of this, monitoring for this project is conducted continuously for three years at six sites. Three of these sites are located in urban areas with the other three sites located in more rural locations. Hg wet deposition is collected at all six sites using daily event precipitation sampling systems. At two of the sites, speciated measurements of ambient Hg (gaseous elemental Hg, RGM, and particulate phase Hg) are collected.

Figure 1. Location of Mercury Monitoring Sites.



Currently, Michigan lacks any long-term Hg data from urban areas[1]. As part of this project, three urban sites in Michigan have been selected that have limited or no Hg data. These sites are located in Grand Rapids, Flint, and Detroit. Data collection at three rural sites in Dexter, Pellston, and Eagle Harbor provide reliable regional background measurements and continue the long-term Hg data record at these sites. Dexter is located northwest of Ann Arbor and is an excellent site used for investigating long-range transport into the state that impacts Michigan's water bodies. Pellston is located in Michigan's northern Lower Peninsula and is representative site for Michigan's rural ambient Hg levels.

Eagle Harbor is located in Michigan's Upper Peninsula on the Keweenaw Peninsula and provides a background measure of relatively clean air masses that ascend on the state from the north. Figure 1 displays the location of the sites operated for this study.

The long-term records at Dexter, Pellston, and Eagle Harbor are critical to the urban monitoring as it provides the relevant climatological context to interpret the urban levels. It is not clear at this point in time how much of the Hg deposition in urban areas is generated in those urban centers and how much is attributable to regional sources and long-range transport. Operation of the sites located at Pellston and Eagle Harbor are also critically important for temporal trends and to facilitate loading estimates for the total maximum daily loads (TMDL) determination for Michigan's inland lakes located in the upper peninsula as well as the states northern lower peninsula. Most inland lakes that have been identified by the Clean Water Act's (CWA's) 303d's list for TMDL determination are located in Michigan's Upper Peninsula and Michigan's northern Lower Peninsula.

In addition to quantifying wet deposition on a daily event basis at the six sites in Michigan, enhanced speciated ambient Hg measurements are performed at two of the sites, Detroit and Dexter. Measurements of elemental Hg and RGM as well as particulate Hg provide data critical to a development of the total impacts of urban areas on downwind ecosystems. Methods for RGM have only become available over the past three years. Modeling estimates for the Lake Michigan Mass Balance Study (LMMBS) revealed that dry deposition of RGM resulted in Hg loadings to the lake approximately equal to the wet deposition loadings. Near large sources or urban/industrial areas, the dry deposition of RGM may exceed the wet deposition input to downwind lakes. The lack of ambient data precludes the scientific and regulatory communities from reducing the largest source of uncertainty in the past and

[1] Approximately nine months of Hg data was collected in Detroit as part of a Hg Minimization program by the City of Detroit Water and Sewerage Department. RGM was not measured in that study.

present TMDL and mass balance studies. Furthermore, limited data collected in Detroit indicated that dry deposition of Hg bound to particulate matter also significantly contributed to the total atmospheric deposition in the city and to levels of Hg in urban runoff.

b. To perform a Pilot Study at an inland lake near urban source(s) of Hg. The selected lake, Orchard Lake (in Oakland County), has elevated Hg tissue concentrations in fish and no known point discharge of Hg. This project is consistent with the Surface Water Quality Division's (SWQD's) strategic environmental quality monitoring program for Michigan's surface waters and compliments this effort. The SWQD is currently charged with the development of TMDLs for inland lakes with consumption advisories due to Hg as required under the CWA. Only wet deposition is conducted at this site.

Public Benefits and Implications: One of the public benefits of this project provides speciated ambient Hg data to the state and local governments for assistance in determining background levels in urban areas where multi-pathway risk assessments may be conducted. Additionally, this data will be useful to compare modeled values from national or regional programs such as the EPA's National Air Toxics Assessment project that assesses ambient air concentrations for census tracts based on dispersion modeling.

Finally, $PM_{2.5}$ samples collected onto Teflon filters are obtained from the ambient sites to allow for subsequent analysis by an inductively coupled plasma-mass spectrometer (ICP-MS). This elemental data will provide additional information on the levels of other ambient toxic elements as well as providing needed data for identifying the sources of the Hg and other elements collected in the urban communities. This data will also be available for identifying the sources or source regions of the measured Hg with the application of meteorological and receptor modeling techniques.

Annual reports are generated that summarize the data collected for each of the three years. Joint peer-reviewed publications from this investigation will also be a major goal of the project. The data will be presented at scientific meetings such as the International Association of Great Lakes Researchers and other forums such as the Binational Strategy meetings that include many stakeholders in the Great Lakes Basin and Ontario. The information will also be organized in a fashion that allows it to be accessible through the MDEQ-AQD's air toxics web site.

III. Methodology

The collection and analysis of atmospheric Hg samples requires specific expertise and specialized laboratory facilities. The UMAQL has developed the analytical and sampling capabilities for performing ultra-trace analysis of Hg in environmental samples. All sample preparation and handling is performed in a Class 100 clean room equipped with state-of-the-art Hg and trace element analytical instrumentation.

Precipitation samples are collected using a wet-only precipitation sampler developed at the UMAQL. The collector allows for separate samples to be simultaneously collected into multiple bottles for Hg and trace element determinations. Samples are collected directly into discrete sampling bottles that are pre-cleaned using the rigorous trace element protocol (6). Each precipitation sample is analyzed for total Hg and for a suite of trace elements (As, Cd, Pb, V, Cr, Ni, Mn, etc.). Samples for Hg are determined using cold vapor atomic fluorescence spectroscopy, as previously described (7). Samples for trace element determinations are analyzed using an ICP-MS, with pre-concentration as previously described (6).

Speciated ambient Hg concentrations are determined using automated sampling techniques. A Tekran 2537/1130/1135 continuous Hg speciation system is used at the two sites to quantify the levels of elemental, RGM, and particulate mercury. The 1130 RGM module uses a KCl-coated annular denuder to selectively collect and quantify the RGM separately from the elemental Hg concentration, while also allowing independent collection and analysis of particulate Hg via the 1135 module.

IV. Progress Report and Preliminary Data

Summary of Accomplishments During this Period

Specialized equipment and supplies for precipitation sample collection and analysis were purchased, received, assembled, and tested during this first year. Final monitoring site selection was completed. Site installation and sample collection for Hg and other trace elements in precipitation began in July 2001 at the Dexter, Pellston, and Eagle Harbor monitoring sites and March 2002 at the Grand Rapids site. Site installation activities for the Flint site began in July 2002, with sample collection beginning in August 2002.

Equipment and supplies for ambient Hg speciation and analysis were purchased in February 2002 and received from Tekran Inc. (Toronto, Ontario) in July 2002. Both sets of 2537/1130/1135 ambient Hg speciation systems were tested and evaluated in the laboratory and were then field tested on-site in Detroit during July 2002. Measurements were performed in Detroit during July 2001 and July 2002 to field test instrumentation and to evaluate methods for particulate Hg measurement.

Problems Encountered During This Period

Site installations were delayed at the Flint and Detroit monitoring sites due to MDEQ site reconstruction and negotiation of access agreements at these two locations. Reconstruction activities at the Flint site are on hold. At this time, site installation activities began with start of sample collection in August 2002. MDEQ monitoring site construction at the Detroit site is scheduled to be completed in September 2002, with site installation and start of sample collection in October 2002.

Sample Collection, Analysis, and Preliminary Data

Table 1 provides a summary of precipitation collection and analyses for Hg and other trace elements compiled through July 9, 2002.

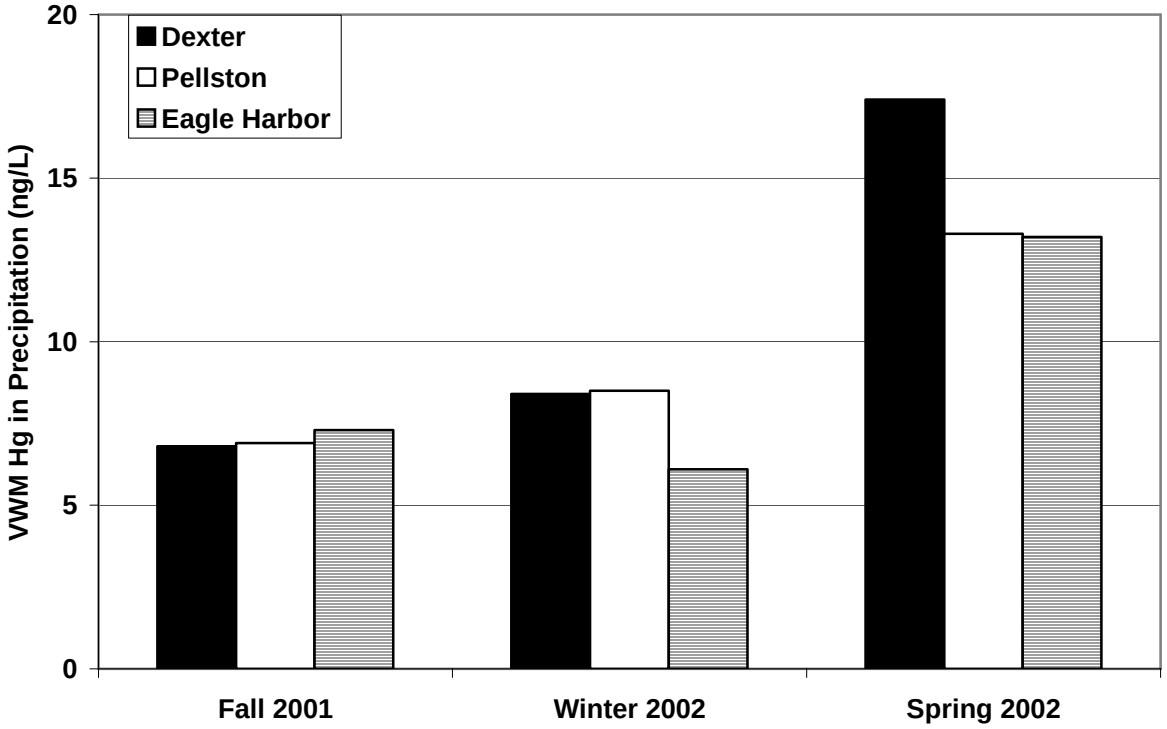
Table 1. Summary of Precipitation Collection and Analysis

	Dexter	Pellston	Eagle Harbor	Grand Rapids	Flint	Detroit	Totals
Samples Collected	72	59	78	34	0	0	243
Hg Samples Analyzed	71	58	76	33	0	0	238
Hg Samples Replicated	17	12	15	9	0	0	53
Trace element Samples Analyzed	22	15	23	21	0	0	81

In total, 243 precipitation samples have been collected from the sample start date of July 1, 2001 through July 9, 2002 across all of the study sampling sites. Of these, 99% of the samples collected have been analyzed for Hg, with about 27% of the samples being analyzed in replicate, as per the Hg analysis replication rate of 25% for this project. Also, 40% of the precipitation samples collected over this period have been analyzed for trace elements using the ICP-MS.

Figure 2 is a plot of the volume-weighted mean (VWM) Hg concentration determined in precipitation by season for the period 10/01/01 to 07/09/02 at the Dexter, Pellston, and Eagle Harbor sampling sites.

Figure 2. Volume-Weighted Mean Hg Concentrations in Precipitation by Season (2001-02).

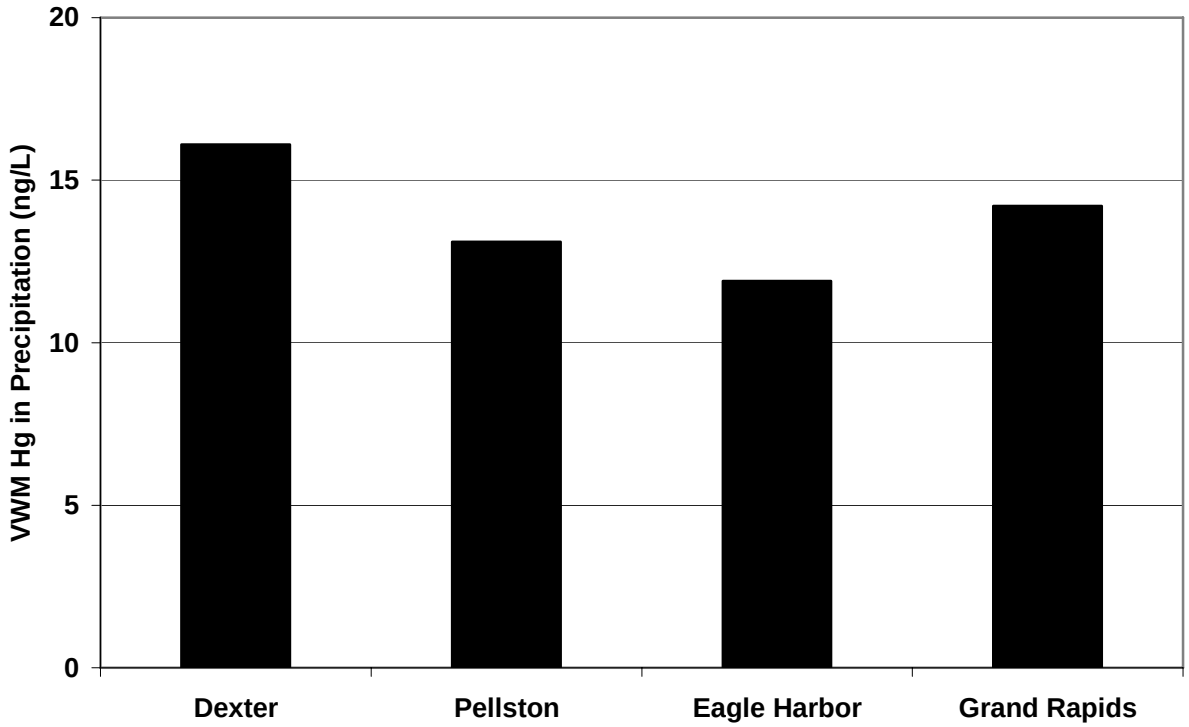


Over the first three complete seasons of precipitation sampling at these three rural sampling sites, the VWM Hg concentrations are in-line with previous data reported at these sites for the fall, winter, and spring seasons. During the Fall 2001 season, all three sites reported a similar VWM Hg concentration near 7 nanograms per liter (ng/L). During the Winter 2002 season, a lower VWM Hg concentration was observed at the Eagle Harbor site (6.1 ng/L) relative to the Dexter and Pellston sites. This observation would be expected as the Eagle Harbor site receives relatively clean air masses from the north during this season. With warming temperatures in the Spring 2002 season, Figure 2 illustrates increased VWM Hg concentrations at all three sites (13-17 ng/L). With inclusion of the summer 2002 data collection, we would expect all three sites to continue to increase in VWM Hg concentration, as previous studies have demonstrated the significant seasonal variations in precipitation Hg concentrations, with highest levels occurring during the summer months. Also, the observation of the north to south increasing gradient in precipitation Hg concentrations, with Dexter having the highest levels, is also consistent with previous data. This observation is due to the difference in impact at each of the sites from regional air masses and distances from regional sources. These results demonstrate why it is

critical to have a north to south line of sampling sites to use with TMDL concentrations for Michigan lakes based on their geographic latitude.

Figure 3 is a plot of the VWM Hg sample concentration in precipitation for the period 03/01/02 to 07/09/02 at the Dexter, Pellston, Eagle Harbor, and Grand Rapids sampling sites. This time period was selected for illustration so as to compare across the four sites as of the start of sample collection at the Grand Rapids site in March 2002.

Figure 3. Volume-Weighted Mean Hg Concentrations in Precipitation (3/1/02 – 7/9/02).

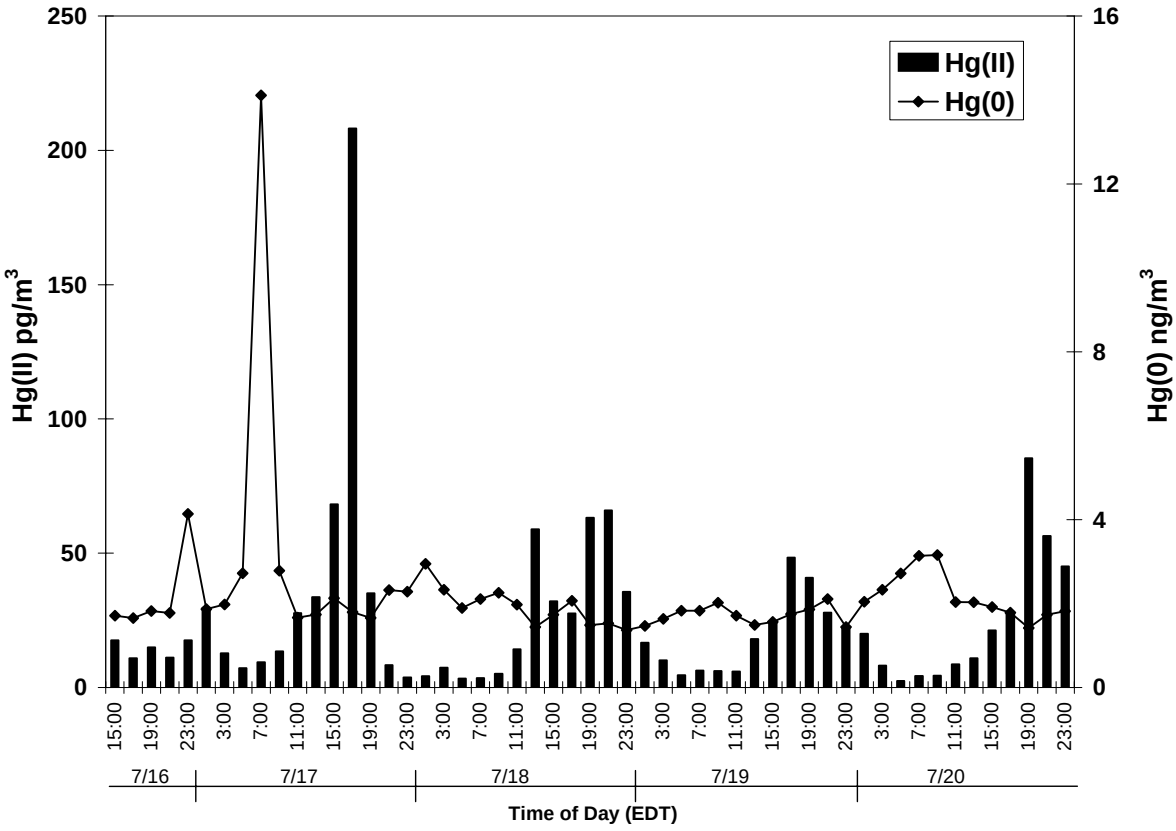


Although Figure 3 represents only four months of data collection, we observed the urban Grand Rapids site to have higher VWM Hg in precipitation when compared to the more rural Pellston and Eagle Harbor sites over this period. Although the Dexter site maintains the highest VWM Hg out of the four sites for this period, it should be noted that the overall total wet deposition of Hg at the Grand Rapids site was actually higher than the Dexter site due to the higher amounts of rainfall at the Grand Rapids site for this sampling period. Cleary, additional on-going data collection at the Grand Rapids site will lend further insight into the role of local urban sources near Grand Rapids and the contributions they make to Hg deposition above the regional background.

While precipitation sample collection began at the Flint site in August 2002, there are no data to report for that site at this time. However, there are preliminary data collection activities to report from Detroit. As part of the sample site selection process, preliminary data for speciated gas phase ambient Hg were collected as part of complimentary measurements performed in support of a project funded by the Health Effects Institute. Preliminary speciated gaseous Hg data were collected at a site in southwest Detroit in July 2001. Figure 4 illustrates the speciation of gaseous Hg in Detroit for the period 7/16/01 to 7/20/01. As is clearly seen in the figure, there were large impacts from local Hg sources on 7/17/01, as the Hg(0) concentration peaked at 14 nanograms

per cubic meter (ng/m^3). More impressive was the RGM peak of over 200 picograms per cubic meter (pg/m^3) reported on this day. This level of RGM in Detroit is similar to maximum levels observed previously in downtown Baltimore during plume impaction by a nearby municipal waste incinerator (8). Clearly, these preliminary data in Detroit confirm the need for long-term monitoring of Hg within this particular location of Detroit. Based on these results, we have selected a long-term monitoring site within one mile of the site of preliminary data collection. This site is in local proximity to large pollutant point sources including power plants, refineries, incinerators, diesel truck traffic, and other manufacturing processes.

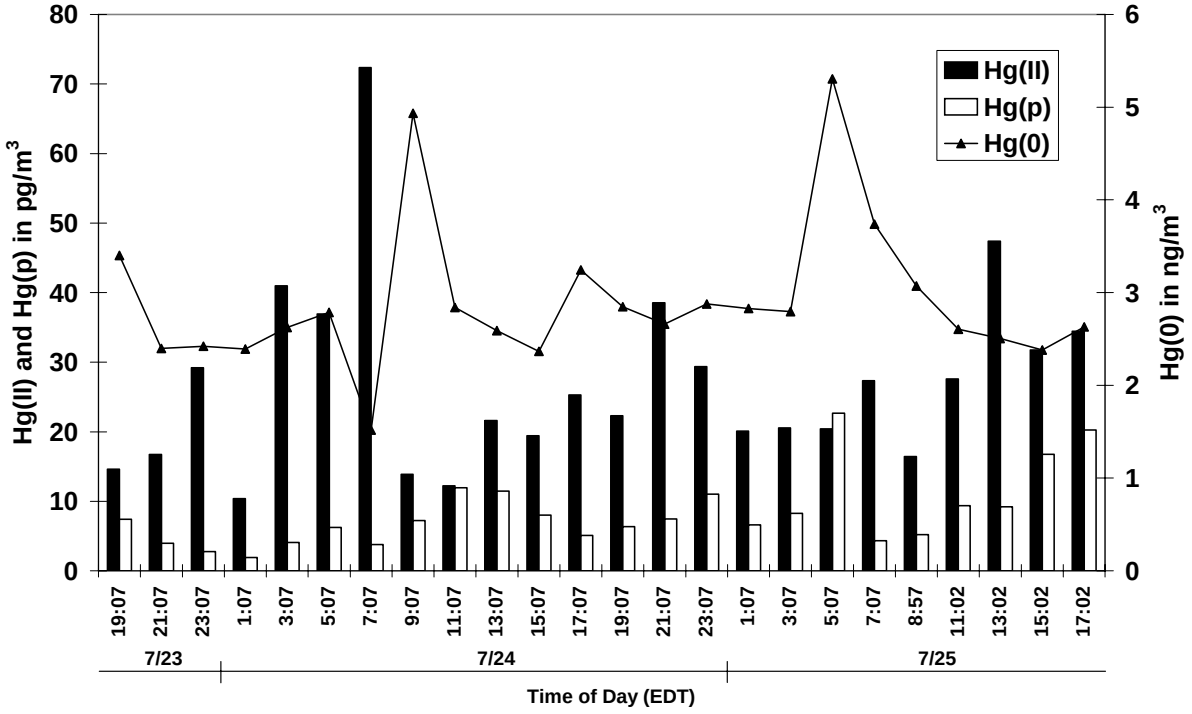
Figure 4. Speciated Mercury Measurements Collected in Detroit 7/16/01 to 7/20/01.



Since site reconstruction of the selected Detroit monitoring site was not scheduled to be completed until September 2002, we again took advantage of the opportunity to collect additional Hg data in July 2002 at the Detroit site of the July 2001 data collection, this time in association with a project funded by the Michigan Life Sciences Corridor. Figure 5 illustrates the speciation of gaseous and particulate Hg collected at the southwest Detroit site using the Tekran speciation systems that were purchased for this project and that will be used for long-term monitoring, including one system to be installed at the selected Detroit site when the site is made available for sampling in October 2002. As seen in the figure, there were two sharp increases in Hg(0) from roughly 2 ng/m^3 up to over 5 ng/m^3 on each morning of 7/24/02 and 7/25/02. These short-term, sharp increases are indicative of impacts by local sources. Also, in addition to the diurnal pattern observed in both Hg(II) and Hg(p), there was one large spike in Hg(II) to 72 pg/m^3 in the early morning hours of 7/24/02, again resembling the data structure expected of impact from a nearby emission plume. While this data collection provided more useful preliminary data, it also

provided for a very productive field testing of the new Tekran instrumentation within an urban airshed, prior to their long-term field deployment. It should also be noted that during the 10 day period 7/21/02 to 7/30/02, a total of six precipitation samples were collected at the Detroit site. Although only 6 samples, they averaged 16.3 ng/L in Hg concentration. These preliminary precipitation samples provide an estimation of the elevated Hg values that we should expect to observe at the long-term Detroit monitoring site.

Figure 5. Speciated Mercury Measurements Collected in Detroit 7/23/02 to 7/25/02.



V. Project Schedule and Timeline

All sampling equipment and supplies were purchased, assembled, and tested, both in the laboratory and in the field, during Year 1. With all six sampling sites fully operational and collecting data at the end of Year 1 (after start-up at Flint and Detroit), three full years of continuous data collection will occur during Years 2 – 4 of the project.

In addition to submission of annual reports, all data collected as part of this project will be presented at the end of year four as part of a project final report. Peer-reviewed journal articles will be prepared and submitted to appropriate journals and results will be presented at annual scientific meetings and conferences, such as the world conferences on "Mercury as a Global Pollutant." Efforts will also be made to include a summary of the data on the MDEQ-AQD's web site. The target audience will be a combination of fellow atmospheric mercury scientists, federal, state and local governmental representatives interested in mercury pollution and the public.

VI. Relevancy and Linkages

Prior to this project, Michigan lacks any long-term Hg data from urban areas. The long-term records at Dexter, Pellston, and Eagle Harbor are critical to the urban monitoring as it provides the relevant climatological context to interpret the urban levels. It is not clear at this point in time how much of the Hg deposition in urban areas is generated in those urban centers and how much is attributable to regional sources and long range transport. Continued operation of the sites located at Pellston and Eagle Harbor are also critically important for temporal trends and to facilitate loading estimates for the TMDL determination for Michigan's inland lakes located in the Upper Peninsula and the northern Lower Peninsula. Most inland lakes that have been identified by the CWA's 303d's list for TMDL determination are located in Michigan's Upper Peninsula and Michigan's northern Lower Peninsula.

In addition to quantifying wet deposition on a daily event basis at the six sites in Michigan, enhanced speciated ambient Hg measurements of elemental Hg and RGM as well as particulate Hg provide data critical to a development of the total impacts of urban areas on downwind ecosystems. Methods for RGM have only become available over the past three years. Modeling estimates for the LMMBS revealed that dry deposition of RGM resulted in Hg loadings to the lake approximately equal to the wet deposition loadings. Near large sources or urban/industrial areas, the dry deposition of RGM may exceed the wet deposition input to downwind lakes. The lack of ambient data precludes the scientific and regulatory communities from reducing the largest source of uncertainty in the past and present TMDL and mass balance studies.

In spring of 2002, the UMAQL (PI: Gerald Keeler) was awarded a USEPA STAR grant to model the atmospheric chemistry, transport, and deposition of Hg in the Great Lakes. This modeling grant will make use of the long-term Hg deposition data collected as part of this MGLPF project at the six sampling sites in Michigan. The MGLPF grant deposition data will provide a critical means to evaluate and validate the Great Lakes modeling results from the USEPA STAR project. In addition, in summer of 2002 the UMAQL (PI: Gerald Keeler) was awarded a USEPA cooperative agreement contract to set-up a Hg super-site in southeast Ohio to monitor the direct impacts of coal combustion emissions from the Ohio River Valley and Midwest U.S. on Hg deposition. This site will begin sample collection in fall of 2002 and will provide long-term data on Hg in wet and dry deposition, speciated ambient Hg, as well as several other co-pollutants. This Ohio site will provide in a sense a "seventh" sampling site to the existing MGLPF Hg monitoring network, as it will extend the existing north/south sampling grid further south into Ohio, adding to the power of both data-sets the ability to determine anthropogenic source contributions from both regional sources as well as those from local urban sources, and their impacts on downwind Hg deposition to inland water bodies and the Great Lakes. Combined, these three projects will make-up a truly unique (worldwide) data collection/modeling network, in terms of collecting long-term event-based Hg deposition data and speciated ambient Hg data at several sites in a temperate climate with direct application to such a sensitive ecosystem as the Great Lakes Basin.

VII. Budget Item Justification

	Year 2
A. SALARIES AND WAGES	
U of M Personnel	
Keeler, P.I (1 month of Year 2)	$ 11,177
Dvonch, CO-PI (30% Year 2)	$ 16,500
Barres, Lab. Manager (40% Year 2)	$ 21,632
Julie Peterson, Technician (100% Year 2)	$ 36,400
Minghao Zhou, Technician (100% Year 2)	$ 37,307
Data Processor (15% Year 2)	$ 6,490
Secretarial (25% Year 2)	$ 6,500
GSRA (50% Year 2)	$ 20,336
AQD Personnel	
CO-PI (40% of .5 FTE Year 2)	$ 9,100
CO-PI (20% of .5 FTE Year 2)	$ 4,550
Senior Associate (40 % of .5 FTE Year 2)	$ 9,100
B. Fringe Benefits	
U of M Personnel	$ 46,522
AQD Personnel	$ 11,530
C. Total Salaries, Wages, and Fringe Benefits (A plus B)	$ 237,144
D. Nonexpendable Equipment (Attach supporting data)	
E. Materials and Supplies	
Office Supplies(copying, paper, ink cartridges etc.)	$ 1,248
Quartz denuders and particulate Hg assemblies for speciation unit	$ 6,304
Laboratory gases (Ar) and coating reagents	$ 6,240
Bottles and funnels (incl. cleaning)	$ 15,600
Analysis Supplies (Ultrapure Acids, etc)	$ 17,784
F. Travel	
Travel for Site Maintenance/Audits	$ 7,000
Annual Meetings/Conferences	$ 3,000
G. Services or Consultants	
H. Computer Costs	
I. All Other Direct Costs	
GSRA Tuition (2 Terms Year 2)	$ 9,551
J. Total Direct Costs (C through I)	$ 303,871
K. Indirect Costs	$ 58,864
TOTAL AMOUNT OF YEAR 2 REQUEST (J plus K)	$ 362,735

VIII. Details of Budget Item Justification

PERSONNEL: All permanent salaries (except the Graduate Student Research Assistant) are calculated on the base salary and at a 32% fringe rate. A 4% cost of living increase has been applied to each subsequent year following the first year.

Gerald Keeler, PhD - Overall direction of the project is provided by Dr. Keeler, who serves as Principal Investigator. Dr. Keeler provides expertise on the atmospheric transport and deposition of mercury, with a focus on source identification. Dr. Keeler has ultimate responsibility for the research and operational activities of the project, including selection and supervision of project

staff, control of laboratory space and equipment, and accountability to the grantor for the proper use of resources provided to the project. Dr. Keeler will be funded at 8.3% FTE (1 month per year) for Year 2 from the grant.

Timothy Dvonch, PhD - Dr. Dvonch serves as Co-Principal Investigator for the project, and assists Dr. Keeler in overall direction of the project's activities. Dr. Dvonch contributes expertise in atmospheric mercury speciation methodologies and has extensive experience in carrying out urban Hg source apportionment studies. Dr. Dvonch will be funded at 30% FTE for Year 2 from the grant.

James Barres, MS - Mr. Barres serves as the Laboratory Manager for the project, and is responsible for field sampling and laboratory protocols, quality assurance/quality control procedures, and proper maintenance of analytical equipment. Mr. Barres will be funded at 40% FTE for Year 2 of the grant.

Laboratory Technicians - Two Laboratory Technicians will be funded at 100% FTE for Year 2 of the grant. The Laboratory Technicians are responsible for carrying out chemical analyses of the precipitation and filter samples collected.

Data Manager - A Data Manager will be funded at 15% FTE for Year 2 of the grant. The Data Manager is responsible for all post-analysis data processing and provides statistical support and assistance to the project Investigators.

Research Secretary - A Research Secretary will be funded at 25% FTE for Year 2 of the grant and provides secretarial and administrative assistance to the Investigators and other laboratory personnel based at the U of M.

Graduate Student Research Assistant - A doctoral-level graduate student based at the U of M School of Public Health will be funded at 50% FTE for Year 2 of the grant. The Graduate Student Research Assistant assists the project Investigators and staff in all aspects of the project. Fringe benefits for the Graduate Student Research Assistant have been calculated at $250 per month for 12 months of Year 2.

MATERIALS AND SUPPLIES:

Office Supplies - Research office supplies (including diskettes, copying and printing, paper, ink cartridges, postage, and telephone) will be purchased at a cost of $1248 in Year 2 of the grant.

Field Supplies - Field sampling supplies (including quartz denuders and assemblies for Tekran 1130/1135/2537 speciation units, precipitation sampling bottles, precipitation sampling funnels, and acid cleaning of bottles and funnels) will be purchased at a cost of $21,904 in Year 2 of the grant.

Laboratory Supplies - Laboratory supplies (including laboratory gases, reagents, ultrapure acids, and pipettes) will be purchased at a cost of $24,024 in Year 2 of the grant.

TRAVEL:

Site Maintenance and Audits - Travel to the field sampling sites for sample collection, maintenance, and audits will be conducted at a cost of $7,000 in Year 2 of the grant.

Annual Meetings and Conferences - Travel for two project staff in Year 2 to attend an annual scientific meeting and/or conference to present results from the project will be conducted at a cost of $3,000 in Year 2 of the grant (1 trip each for two project staff @ $1,500 each).

OTHER:

GSRA Tuition - This item covers student tuition for the Graduate Student Research Assistant at a cost of $9,551 for Year 2 of the grant (two terms).

IX. References

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8. Dvonch, J.T., Keeler, G.J., Lynam, M., Marsik, F.J. and Barres, J.A. (2001) Real-Time Field Observations of the Production of Reactive Gaseous Mercury (RGM) in Ambient Air. Conference Proceedings from the Air and Waste Management Association's Conference on *"Mercury Emission: Fate, Effects, and Control"*, August 21-23, Chicago, Illinois.